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(54) **Pump assembly**

(57) housing sub-assembly for a pump assembly (230) for use in a selective catalytic reduction system, the housing sub-assembly comprising: a main body (232) having a pump axis (A), the main body comprising a pumping zone cavity (248) having a main axis substantially coincident with axis A, and comprising a flow guide cavity (252) disposed about axis A; an outer pole member (268) and a solenoid coil (264) disposed within the main body (232); wherein the main body further comprises a reagent inlet port (234)for receiving a reagent for supply to the pumping zone cavity (248) via a reagent flow path (246) and first and second coolant ports (236, 238) for supplying coolant to and removing coolant from the flow guide cavity (252); wherein the main body, first and second coolant ports and reagent inlet port are integrally formed as a single component (230).

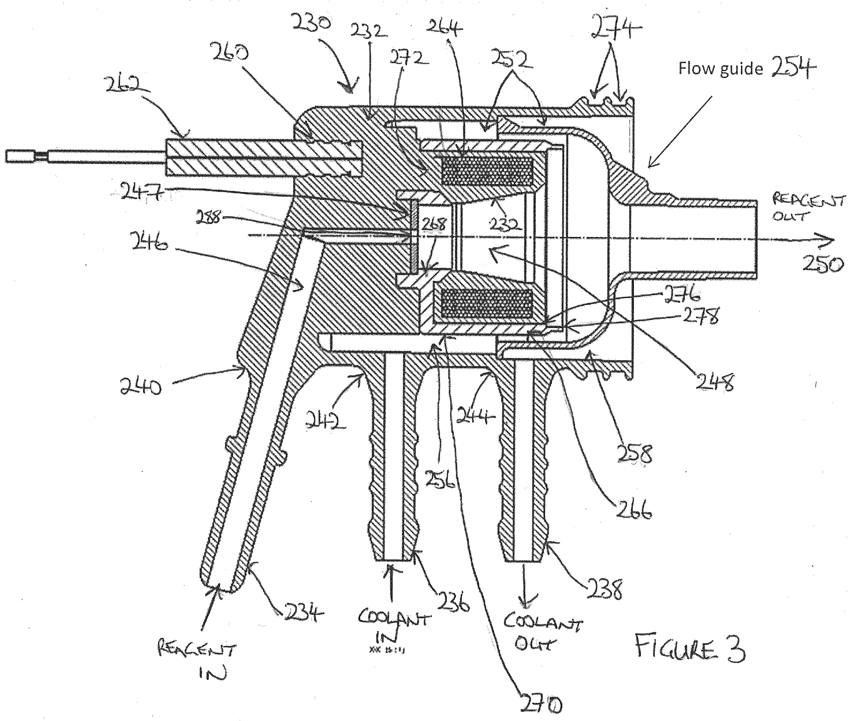

FIGURE 3

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Description

Field of the invention

[0001] The present invention relates to a pump assembly. More particularly, but not exclusively, the invention relates to a dosing pump for a selective catalytic reduction system.

Background to the invention

[0002] It is known that exhaust gases from internal combustion engines contain substances which are harmful to the environment and which can pose a threat to public health. For many years, a sustained effort has been made within the automotive industry to reduce the release to the atmosphere of harmful substances carried in exhaust gases, both by modifying the combustion process itself to give a reduced yield of harmful combustion products, and by treating the exhaust gases before their emission into the atmosphere, for example by providing a catalyst to induce chemical breakdown of the harmful constituents, particularly the oxides of nitrogen (NO_x), into benign compounds.

[0003] One strategy for reducing NO_x emissions, known as selective catalytic reduction or SCR, involves the introduction of a reagent comprising a reducing agent, typically a liquid ammonia source such as an aqueous urea solution, into the exhaust gas stream. The reducing agent is injected into the exhaust gas upstream of an exhaust gas catalyst, known as an SCR catalyst, typically comprising a mixture of catalyst powders such as titanium oxide, vanadium oxide and tungsten oxide immobilised on a ceramic honeycomb structure. Nitrogen oxides in the exhaust gas undergo a catalysed reduction reaction with the ammonia source on the SCR catalyst, forming gaseous nitrogen and water. An example of an SCR system is described in the Applicant's European Patent Application Publication No. EP-A-2131020, the contents of which are hereby incorporated by reference.

[0004] SCR systems typically include a reagent dosing pump for delivering reagent to the exhaust gas stream.

[0005] In one known reagent dosing pump, a solenoid-actuated pumping arrangement is provided to increase the pressure of the reagent, and the pump includes an atomising nozzle that receives the reagent from the pumping arrangement and delivers it from an outlet end into the exhaust gas stream. The nozzle is close-coupled to the pumping arrangement, so that the nozzle and the pumping arrangement form a single unit. The outlet end of the nozzle may be positioned directly in the exhaust gas stream, so that the pumping arrangement is located close to the outside of the exhaust pipe that conveys the exhaust gases.

[0006] Examples of such pumps are described in the Applicant's European Patent Application Publication No. EP-A-1878920, the contents of which are hereby incorporated by reference.

[0007] The pumping work conducted by the dosing arrangement of such solenoid actuated pumps is created by a solenoid coil acting on the magnetic armature of a plunger armature assembly.

[0008] The maximum temperature at which urea-based reducing agents can be used is somewhat limited. Urea crystals tend to precipitate when the temperature of the solution is greater than approximately 70°C. Precipitation is undesirable because the precipitates can cause blockages in the delivery system, for example in the small-diameter outlets typically provided in the outlet end of the atomising nozzle. In addition, the formation of precipitates alters the concentration of the remaining solution, so that the effective quantity of ammonia delivered to the exhaust flow becomes uncertain. This could lead to inefficient catalysis and an insufficient reduction in NO_x emissions.

[0009] It is therefore desirable, in many cases, to provide cooling means to cool the reagent in an SCR system and, in particular, in the reagent dosing pump, to prevent overheating of the reagent. Furthermore, when solenoid-actuated pumping arrangements are used, it is also desirable to cool the solenoid coil since the performance of solenoid actuators can decrease at high temperatures. Many known pump assembly arrangements therefore include a water cooling system, e.g. by means of the provision of a water jacket around the solenoid actuator and the provision of water input and output ports to the jacket in order to provide a flow of cooling water.

[0010] In designing and optimising pump assemblies there are a number of requirements that need to be considered. Firstly, packaging of the pump assembly within the engine system is increasingly challenging. The mass of such an assembly is also important in ensuring the product is robust in its attachment to a thin walled exhaust section, and subsequent vibrations seen in use. And finally, one further issue which is important to the integration of a new water cooled product in such an environment is the heat input in to the water cooling system.

[0011] One area which drives opportunities to improve all of the above points is size and arrangement of the solenoid coil. On the design described in EP1878920, a terminal block is provided to interface between the coil windings of the solenoid coil of the actuator and an electrical supply cable (the solenoid cable). However, this approach increases the packaging size of the coil, and hence the water jacket required to house it. There is therefore a knock on effect which impacts the size, mass and surface area of the doser exposed to the high ambient temperature environment.

[0012] It is therefore an object of the present invention to provide a pump assembly for use in an engine system that substantially overcomes or mitigates the above mentioned problems.

Summary of the invention

[0013] According to a first aspect of the present invention there is provided a housing sub-assembly for a pump assembly for use in a selective catalytic reduction system, the housing sub-assembly comprising: a main body having a pump axis A, the main body comprising a pumping zone cavity having a main axis coincident with axis A, and comprising a flow guide cavity disposed about axis A; an outer pole member and a solenoid coil disposed within the main body wherein the main body further comprises a reagent inlet port for receiving a reagent for supply to the pumping zone cavity via a reagent flow path and first and second coolant ports for supplying coolant to and removing coolant from the flow guide cavity wherein the main body, first and second coolant ports and reagent inlet port are integrally formed as a single component.

[0014] The present invention provides a housing sub-assembly for a pump assembly which incorporates an outer pole member and a solenoid coil. The outer pole member (which may be formed from a material with a relatively high magnetic permeability) and solenoid coil comprise elements of a magnetic circuit that may be used to drive a pumping plunger of the pump array. In known pump arrays the magnetic circuit components would be formed together within a particular sub-assembly component. By placing the outer pole member and solenoid coil within the housing sub-assembly the magnetic circuit may effectively be "split" between the housing sub-assembly and the pumping sub-assembly and the size of the pump assembly reduced. It is noted that the solenoid coil and outer pole member may be arranged to form a magnetic circuit with a pump core located within a pump sub-assembly. The pumping zone cavity may be conveniently dimensioned to receive the pump sub-assembly (and pump core) in order to complete the magnetic circuit of the pump assembly.

[0015] Conveniently, the main body, first and second coolant ports and reagent inlet port may comprise an over-moulding member, the over-moulding member having been formed over the coil and outer pole member. By forming the main body, first and second coolant ports and reagent inlet port as an over-moulding member the need for various sealing members (O ring seals) may conveniently be reduced.

[0016] Conveniently, the over-moulding member may be formed from plastic.

[0017] The housing sub-assembly may further comprise an outer sleeve, the outer sleeve being disposed within the main body about axis A and the solenoid coil being disposed within the outer sleeve.

[0018] Conveniently the flow guide cavity may be defined in part by the main body and by the outer sleeve.

[0019] The outer sleeve and outer pole member may be formed as a single component.

[0020] The outer sleeve and outer pole member may together form a substantially cylindrical component comprising a first open end and a substantially closed second end, the second end comprising a drilling that aligns with one end of the reagent flow path and a machined slot for allowing electrical connection between the solenoid coil and an electrical connector to be made.

[0021] Conveniently electrical connections between the solenoid coil and the electrical connector member may be routed through the main body of the housing sub-assembly and through the machined slot. Where the main body, first and second coolant ports and reagent inlet port comprise an over-moulding member, the electrical connections may be embedded within the over-moulded component.

[0022] The machined slot may conveniently be located off axis A. The pumping zone cavity may be dimensioned to receive a pump core. The pumping zone cavity may be further dimensioned to receive a pumping armature for pumping reagent supplied via the reagent flow path to the pumping zone cavity.

[0023] The housing sub-assembly may further comprise a metallic back plate having a drilling, the reagent flow path being arranged to align with the drilling.

[0024] According to a second aspect of the present invention there is provided a pump assembly for use in a selective catalytic reduction system comprising: a housing sub-assembly according to the first aspect of the present invention and a pump core, the pump core being located within the pumping zone cavity of the housing sub-assembly.

[0025] The pump core may be part of a pump sub-assembly. Other components within the pump sub-assembly may comprise a plunger armature, nozzle tubes and nozzle delivery valves.

[0026] According to a third aspect of the present invention there is provided a method of manufacturing a pump assembly comprising manufacturing a housing sub-assembly by: providing a blank disk member of a material having a relatively high magnetic permeability; deep drawing the blank disk member to form an outer pole piece, the outer pole piece defining an internal volume with an opening; inserting a solenoid coil into the internal volume of the outer pole piece; pressing a back stop plate into the outer pole piece, the back stop plate having at least one drilling through the plate; injection moulding an over-mould member to encapsulate the outer pole piece and solenoid coil and to form a main body of the housing sub-assembly, the main body having a pump axis A and defining a pumping zone cavity having a main axis substantially coincident with axis A, and defining a flow guide cavity disposed about axis A; forming a reagent inlet port as part of the over-mould member; forming coolant ports as part of the over-mould member; forming at least one flow path through the over-moulding member, the at least one flow path aligning with the at least one drilling in the back stop plate.

[0027] The method may further comprise inserting an actuator pump core into the pumping zone cavity defined by the main body of the housing sub-assembly.

[0028] The method may also further comprise inserting a coolant flow guide.

[0029] Preferred and/or optional features of each aspect of the invention may be used, alone or in appropriate combination, in the other aspects also.

Brief description of the drawings

[0030] Embodiments of the present invention will now be described, by way of example only, with reference to the accompanying drawings, in which like reference numerals are used for like parts, and in which:

Figure 1 shows a known pump assembly;

Figure 2 shows a further known pump assembly useful for understanding the present invention;

Figure 3 shows a pump assembly in accordance with an embodiment of the present invention;

Figure 4 shows a component of the pump assembly of Figure 3 in more detail.

Detailed description of embodiments of the invention

[0031] A known pump assembly 10 is shown in Figure 1.

[0032] Referring Figure 1, the pump assembly 10 includes a reagent dosing unit with an integrated pump and nozzle arrangement, referred to hereafter as a reagent dosing pump sub-assembly 12. The pump sub-assembly 12 is a reagent dosing pump of any suitable type, for example as described in EP-A-1878920, to which reference can be made for further details of the pump sub-assembly 12.

[0033] The pump sub-assembly 12 comprises a pump housing 14 having a generally cylindrical pump body portion 16 that defines a pump axis (axis A in Figure 1), and a generally cylindrical nozzle portion 18 that extends from a first face 20 of the body portion 16 along the pump axis A. The nozzle portion 18 has a relatively small diameter compared to the body portion 16.

[0034] The body portion 16 of the pump housing 14 houses a pumping mechanism (not shown), such as a solenoid-actuated pumping mechanism. In use, the pumping mechanism receives reagent through a reagent inlet 22 provided on a second face 24 of the body portion 16, opposite the first face 20. An electrical connection point 26 is also located on the second face 24 of the body portion 16, to provide an operating current to the solenoid actuator of the pumping mechanism. As is known from EP-A-1878920, the pumping mechanism includes a reciprocating pumping element, such as a plunger or piston, and is arranged to increase the pressure of a predefined quantity of reagent on each cycle of the pumping element.

[0035] The nozzle portion 18 of the pump housing 14 houses a delivery passage (not shown) that, in use, receives the pressurised reagent from the pumping mechanism, and conveys it to a reduced-diameter outlet end 28 of the nozzle portion 18. The outlet end 28 houses an atomising nozzle that atomises the reagent as it exits the pump sub-assembly 12.

[0036] The pump assembly 10 also includes a housing sub-assembly 30 having an internal cavity 32 in which the pump 12 is received. The cavity 32 is defined by an internal wall 34 of the housing sub-assembly 30. In general terms, the shape of the cavity 32 is an enlarged version of the shape defined by the pump housing 14. In this way, the internal wall 34 of the cavity 32 is spaced from the pump housing 14 to define a volume/compartment 36 for cooling fluid therebetween.

[0037] The housing sub-assembly 30 is generally made from cast stainless steel.

[0038] In a region of the housing sub-assembly 30 remote from the outlet end 18 of the pump, a projection or land 40 extends axially from the internal wall 34 of the cavity 32 towards the outlet end 18 of the pump, to meet the inlet port 22 on the second face 24 of the housing pump body portion 16. A collar 42 is provided on the second face 24 of the pump body portion 16 that receives the land 40. An O-ring 44 is provided to create a fluid-tight seal between the collar 42 and the land 40. The O-ring 44 is received in an annular ring 46 machined into the body of the housing sub-assembly 30.

[0039] The seal provided by the O-ring 44 prevents leakage of reagent into the compartment 36 between the land 40 of the housing sub-assembly 30 and the collar 42 of the pump housing 14.

[0040] The end of the housing sub-assembly 30 remote from the outlet end 18 comprises a connection block 50 of generally cuboidal shape. A top face of the connection block 50 is provided with a reagent inlet port 52 that receives a tubular reagent inlet connector 54.

[0041] The inlet connector 54 extends radially with respect to the pump axis A and is connected to a reagent supply line (not shown) in use.

[0042] A filter 55 is located in the flow path between the inlet connector 54 and the reagent inlet 22 of the pump 12. In this embodiment, the filter 55 is received in the inlet port 54. The filter 55 is conveniently a disc filter, arranged to prevent particulate contaminants in the reagent, such as urea crystals, from entering the pump 12.

[0043] The connection block 50 is also provided with a drilling 56 to admit an electrical connector 58. The electrical connector 58 connects with the electrical connection point 26 of the pump 12. A further O-ring 60 is provided to seal the electrical connector 58 in the drilling 56. The O-ring 60 is again provided in an annular groove 62 provided in the body of the housing sub-assembly.

[0044] Figure 2 shows a pump assembly 100 in accordance with an example useful for understanding the present invention. Like features between Figures 1 and 2 are referred to with reference to the same reference numerals

[0045] The pump assembly 100 of Figure 2 comprises a pump sub-assembly 12 contained within a water cooled housing sub-assembly 30.

[0046] The pump sub-assembly 12 comprises an over-moulding member 102 and a solenoid actuator 103, the solenoid actuator 103 comprising: an actuator core (also referred to as pump core or inner pole piece) 104, an outer pole piece 106, a magnetic sleeve 107, a bobbin 108 and a solenoid coil 110, the solenoid coil being carried on the bobbin. The components of the actuator are, in turn, supported by the over-moulding member. A pumping region 112 within the pump sub-assembly 12 is provided by a volume defined by the outer pole piece 106, a back plate member 114 and a top face 115 of the actuator core 104. A bore 116 is provided within the actuator core 104. At the end of the bore remote from the pumping region 112 is a pumping chamber region 118.

[0047] The housing sub-assembly 30 comprises a cavity 120 for receiving the pump sub-assembly 12, the cavity being dimensioned such that a compartment 122 is defined between the housing 30 and pump 12 sub-assemblies in the general region of the solenoid actuator 103. In use, a coolant, e.g. water, is supplied via a hydraulic connector (not shown in Figure 2) to the compartment 3 to provide water cooling of the actuator.

[0048] The housing sub-assembly 12 comprises a reagent inlet port 52 wherein a reagent connector (not shown) can be interfaced with the housing sub-assembly 30 in order to supply a reagent, e.g. Adblue reagent.

[0049] The pump sub-assembly 12 further comprises a neck portion 124 remote from the solenoid actuator, the neck portion being dimensioned to be received within a drilling 126 in the body of housing sub-assembly 30. The neck portion 124 in turn comprises a bore 128 that is coincident with the pump assembly axis A. In use, the bore 128 receives an electrical connector cable 58 for connection to terminals of the solenoid coil wire 110.

[0050] The reagent flows from the inlet port 52 through a second drilling 130 in the housing sub-assembly 30 to a radial gallery 132 defined between the housing sub-assembly 30 and the neck portion 124 of the pump sub-assembly 12. The gallery 132 permits assembly of the pump sub-assembly into the housing sub-assembly and also allows orientation of the pump sub-assembly relative to the housing sub-assembly during this process.

[0051] The reagent gallery 132 is sealed from the outside environment in the region of the neck portion 124 by two O ring seals (134, 136) and sealed from the main housing water chamber 122 via a third O ring seal 138, all of which are retained by suitable O Ring grooves 140 moulded as part of the coil over-moulding member 102. Although, two O rings are shown (134, 136) in the neck portion 124 of the pump sub-assembly, it is noted that a single O ring seal would be sufficient for this primary function.

[0052] From the gallery 132, reagent is then routed through the coil over-moulding member 102 via a number of flow ports 142, one of which is visible in Figure 2. It is however noted that three or four ports could be provided equispaced around the axis A to provide efficient fluid communication between the gallery 132 and the internal pumping region 112 of the pump sub-assembly 12.

[0053] As reagent exits the flow port 142 it then passes through a drilling 144 in the non magnetic plunger back stop plate 114 before entering the pumping region 112. With the reagent delivered to the pumping zone 112, the flow path resumes the route as described in EP1878920. Note that the drilling 144 may be a port that is drilled or manufactured by other means (e.g. produced by stamping/fine blanking etc.).

[0054] It is noted that the drilling 144 in the back plate 114 is arranged during assembly to line up with the port 142 in the over-moulding member 102. In the event of multiple ports 142 the back stop plate would comprise an equal number of drillings 144 in the same orientation as the ports 142.

[0055] The over-moulding member 102 is formed via an injection moulding method. One potential method for manufacturing the ports and aligning them with the drillings 144 of the back stop plate 114 would be to align the drillings 144 of the back plate 114 with the removable cores of a mould tool when injection moulding the over-moulding member 102. Alignment is important as it permits the routing of the solenoid coil cable 58 to the coil wire terminals (not shown) which would need to pass within (in between) the gaps of the reagent ports 142.

[0056] To allow the assembly of the plunger back stop accurately and for the solenoid to operate correctly the magnetic outer pole piece 106 and magnetic outer sleeve 107 are formed from one deep drawn component, which also incorporates a locating face 146 and crimp feature 148 for the pump core 104. Forming the outer pole piece 106 and magnetic outer sleeve 107 via a deep draw process reduces material waste compared to a process where the components are formed by machining.

[0057] The pump sub-assembly 12 may therefore be assembled by winding the coil wire 110 around the coil former or bobbin 108. The wound coil former (110, 108) can then be slid into the magnetic drawn component 107, which will have a slot (not shown in this view) to receive the bobbin terminals. Then with the back plate 114 in place, and flow port 142 cores aligned to the back plate ports 144 over moulding will take place over the whole pump sub-assembly 12. Holes 150 in the magnetic outer sleeve 107 permit filling of the volume 152 between the coil windings 110 and the outer sleeve inside face 107.

[0058] The axial positioning of the coil wire 58 allows the water cooled cavity 122 within the housing to be optimized and sized primarily for the purposes of cooling. The overall outside diameter of the housing sub-assembly 30 may therefore be reduced.

[0059] As noted above, the pumping mechanism of the pump sub-assembly is known from, for example EP-A-1878920. Briefly however, a supply passage 154 is defined by an annular cavity between the coil former 108 and the actuator core 104. A plurality of filling ports 156 (of which one is shown in Figure 2) comprising a radial through bore, extend from the axial bore 116 to the supply passage 154.

[0060] A reciprocating pumping element, such as a plunger or piston (not shown in Figure 2) is slidably accommodated within the bore 116. A disc-shaped armature (also not shown in Figure 2) is attached to the plunger.

[0061] In order to dispense reagent, a current is passed through the solenoid coil 110 to energise the coil and induce a magnetic field around the coil. The resulting magnetic field exerts a force on the armature which, in turn, drives a pumping stroke of the plunger. By means of the reciprocating plunger reagent is pumped from the internal pumping region 112 via the passage 154 and ports 156 to the pumping chamber 118 and then out to an adjoining nozzle tube (not shown in Figure 2). A further seal member 158 is provided between the coil former 108 and actuator core 104.

[0062] Figures 3 and 4 relate to an embodiment of the present invention that simplifies the pump assemblies discussed above. The embodiment of Figures 3 and 4 offers a pump assembly that is more compact, has fewer internal components and has improved internal sealing. It is noted that the embodiment of Figures 3 and 4 also has improved external sealing as the over-moulded member as described below removes the need for O ring seals between the reagent/coolant ports and the housing sub-assembly since the connector ports and body of the housing sub-assembly are formed as a unitary piece.

[0063] As can be seen in Figures 1 and 2 a number of O ring seals are required to ensure a fluid tight seal at interfaces between the pump sub-assembly 12 and housing sub-assembly 30 and between the various connectors and the housing.

[0064] In Figure 1, for example O ring seal 46 is provided to create a fluid-tight seal between the collar 42 and the land 40 and O ring seal 60 is provided to seal the electrical connector 58 in the drilling 56 (the O-ring 60 being provided in an annular groove 62 provided in the body of the housing sub-assembly).

[0065] In Figure 2, the reagent gallery 132 is sealed from the outside environment in the region of the neck portion 124 by two O ring seals (134, 136) and sealed from the main housing water chamber 122 via a third O ring seal 138, all of which are retained by suitable O ring grooves 140 moulded as part of the coil over-moulding member 102. A further seal member 158 is provided between the coil former 108 and actuator core 104.

[0066] However, the pump assembly of Figure 3 comprises a housing sub-assembly 230 in which a number of components of the pump assembly have been incorporated into a single over-moulded housing sub-assembly component 230. In effect, in comparison to Figures 1 and 2, the pump sub-assembly has been "split in half" and components from the pump assembly have been moved into the housing sub-assembly. By subsequently over-moulding the components into place the need for the various O ring seals in Figures 1 and 2 above is reduced. The overall size of the housing sub-assembly is thereby reduced in the embodiment of Figures 3 and 4 and the number of interfaces requiring a fluid tight seal is also reduced thereby improving the reliability of the pump assembly and improving the ease of assembly.

[0067] Referring to Figure 3, a housing sub-assembly 230 is provided comprising an over-moulding member 230 which comprises a main body portion 232 and a number of connector ports 234, 236, 238 for a reagent port inlet, coolant inlet and coolant outlet respectively. As can be seen from Figure 3 the connector ports 234, 236, 238 and main body 232 form a unitary piece such that the need for O ring seals at the connector locations 240, 242, 244 is removed.

[0068] The reagent inlet port 234 comprises a flow path 246 which is in fluid communication with a pumping zone 248 (also referred to herein as a pumping zone cavity) which is dimensioned to receive a pump sub-assembly. When the pump assembly has been assembled, the pumping zone comprises the following components: an actuator core (also referred to as pump core or inner pole piece), a plunger armature, a nozzle tube and nozzle delivery valves (not shown in Figure 3) for delivery of reagent from the inlet port 234 to an exhaust flow (direction 250 in Figure 3) [these components may individually or in combination be referred to as the pump sub-assembly]. The flow path 246 passes through a non-magnetic back plate member 247 as described below.

[0069] Coolant inlet and outlet ports 236, 238 are in fluid communication with a cavity 252 (also referred to herein as a flow guide cavity) within the main body 232 of the housing sub-assembly 230 which cavity is dimensioned to receive a flow guide member 254. The flow guide member 254 defines first 256 and second 258 volumes and, in use, coolant fluid may flow in via port 236 and flow first through the first volume 256 and then via the second volume 258 in order to allow excess heat within the pump assembly to be extracted. Coolant fluid may then exit the assembly via port 238.

[0070] The main body 232 of the housing sub-assembly 230 is also provided with a female connection port 260 such that electrical cables can be connected via an electrical connector 262.

[0071] Contained within the housing sub-assembly 230 of the embodiment of Figure 3 are a number of components that were located within the pump sub-assembly in Figure 2. In particular, the housing sub-assembly 230 of Figure 3 comprises a solenoid coil 264, magnetic outer sleeve member 266 (also referred to herein as an outer sleeve), an outer pole piece 268 (also referred to herein as an outer pole member) and a back plate member 247, that is formed from a material with a low magnetic permeability. The coil 264 may be carried on a bobbin (not shown in Figure 3). As shown in Figure 3 the outer sleeve member 266 (which is formed from a material with a relatively high magnetic permeability) and the outer pole piece 268 (also formed from a material with a relatively high magnetic permeability) are actually a single component member 270. It is to be appreciated however that the sleeve member 266 and pole piece 268 may be two separate components that are either attached to one another or held in proximity to one another by the over moulded main body 232 of the housing sub-assembly 230.

[0072] Although the connections are not shown in Figure 3 the electrical connector 262 is connected through a hole 272 in the outer pole piece 268 to the ends of the solenoid coil 264.

[0073] Once the housing sub-assembly has been assembled with a pump sub-assembly the solenoid coil 264, magnetic outer sleeve member 266 and outer pole piece 268 form part of the magnetic circuit that is used to drive the pumping plunger of the pump array.

[0074] Also shown in Figure 3 is a pair of U shaped grooves 274 in the outer surface of the main body of the housing sub-assembly. These are used during installation and assembly to receive a pair of O ring seals between the housing sub-assembly and a front piece portion of the pump assembly (not shown). The magnetic outer sleeve 266 also incorporates a locating face 276 and crimp feature 278 for the pump core (not shown in Figure 3). It is noted that the outer pole piece 268 and outer sleeve 266 may be formed from a single deep drawn component 270, which incorporates the locating face 276 and crimp feature 278 for the pump core. Forming the outer pole piece 268 and magnetic outer sleeve 266 via a deep draw process reduces material waste compared to a process where the components are formed by machining.

[0075] Figure 4 shows the outer sleeve 266 and outer pole piece 268 in more detail. The sleeve and pole piece are formed as a single component 270. The component 270 is generally cylindrical in shape and comprises a first, open end 280 through which the solenoid coil 264 and bobbin may be loaded during assembly. The second end 282 of the component comprises the outer pole piece 268. The outer pole piece incorporates a bore 284 through which reagent may pass in use and also a machined slot 272 through which electrical connections from the coil 264 to the electrical connector 262 may be made during the assembly process.

[0076] The outer surface of the component 270 comprises a number of machined holes 286 (three of which are visible in figure 4).These holes are provided to improve the over moulding process as described below and also enable the outer pole piece 268 and sleeve 266 to be held securely in place within the main body 232 of the sub-assembly 230 once over-moulding has occurred.

[0077] The process of constructing the pump assembly according to Figures 3 and 4 is as follows. A wound coil 264 is introduced into an outer sleeve piece 266 and outer pole piece 268 component (270), the component 270 having a first open end 280 and a second end 282 with a machined orifice 284 and a machined slot 272 (shown in Figure 4). A backstop plate 247, having at least one drilling 288 therethrough is provided at the second end of the component.

[0078] The ends of the wound coil are passed through the machined slot 272 in the component 270 and then connected (e.g. welded) with an electrical connector 262. The coil 264, outer sleeve piece 266, outer pole piece 268, backstop plate 247 and electrical connector 262 are then placed into an over-mould cavity and plastic resin is then introduced into the cavity in order to over mould the main body 232 of the housing sub-assembly 230.

[0079] As part of the assembly process the coil may first be wound onto a coil former. A flow path forming member may also be provided within the over mould cavity in order to provide a flow path 246 from the reagent inlet 234 to a pumping cavity 248 within the outer sleeve 266 and outer pole piece 268. Further flow path forming members may also be provided to define flow paths from coolant inlet/outlet 236/238 to a flow cavity 252 within the main body 232 of the housing sub-assembly 230. The flow path forming members may comprise solid structures within the over-moulding cavity that are arranged to block over-mould from forming in certain areas of the over-moulding cavity. In this manner various passages and flow paths may be formed within the housing sub-assembly.

[0080] As described above in relation to Figure 4 there are a number of machined holes 286 in the outer sleeve piece 266. During the over moulding process plastic resin may flow through these holes 286 into the volume defined within the over sleeve piece 266. After the resin sets there will therefore be a continuous formation of plastic over-moulding material that passes through each of these machined holes 286. This aids retention of the outer sleeve piece 266 within the main body 232 of the housing sub-assembly 230.

[0081] Further variations and modifications not explicitly described above may also be contemplated without departing from the scope of the invention as defined in the appended claims.

Claims

1. A housing sub-assembly for a pump assembly (230) for use in a selective catalytic reduction system, the housing sub-assembly comprising:

   a main body (232) having a pump axis (A), the main body comprising a pumping zone cavity (248) having a main axis substantially coincident with axis A, and comprising a flow guide cavity (252) disposed about axis A;
   an outer pole member (268) and a solenoid coil (264) disposed within the main body (232);
   wherein the main body further comprises a reagent inlet port (234) for receiving a reagent for supply to the pumping zone cavity (248) via a reagent flow path (246) and first and second coolant ports (236, 238) for supplying coolant to and removing coolant from the flow guide cavity

(252);
wherein the main body, first and second coolant ports and reagent inlet port are integrally formed as a single component (230).

2. A housing sub-assembly as claimed in Claim 1, wherein the main body, first and second coolant ports and reagent inlet port comprise an over-moulding member, the over-moulding member having been formed over the coil (264) and outer pole member (268).

3. A housing sub-assembly as claimed in Claim 2, wherein the over-moulding member is formed from plastic.

4. A housing sub-assembly as claimed in any one of Claims 1 to 3, further comprising an outer sleeve (266), the outer sleeve being disposed within the main body (232) about axis A and the solenoid coil (264) being disposed within the outer sleeve (266).

5. A housing sub-assembly as claimed in Claim 4, wherein the flow guide cavity (252) is defined in part by the main body (232) and by the outer sleeve (266).

6. A housing sub-assembly as claimed in Claim 4 or Claim 5, wherein the outer sleeve (266) and outer pole member (268) are formed as a single component (270).

7. A housing sub-assembly as claimed in any one of Claims 4 to 6, wherein the outer sleeve (266) and outer pole member (268) together form a substantially cylindrical component (270) comprising a first open end (280) and a substantially closed second end (282), the second end comprising a drilling (284) that aligns with one end of the reagent flow path (246) and the second end comprising a machined slot (272) for allowing electrical connection between the solenoid coil (264) and an electrical connector (262) to be made.

8. A housing sub-assembly as claimed in Claim 7, wherein electrical connections between the solenoid coil (264) and the electrical connector (262) are routed through the main body (232) of the housing sub-assembly (230) and through the machined slot (272).

9. A housing sub-assembly as claimed in Claim 7 or Claim 8, wherein the machined slot (272) is located off axis A.

10. A housing sub-assembly as claimed in any preceding claim, wherein the pumping zone cavity (248) is dimensioned to receive a pump core.

11. A housing sub-assembly as claimed in any preceding claim, further comprising a metallic back plate (247) having a drilling (288), the reagent flow path (246) being arranged to align with the drilling.

12. A pump assembly for use in a selective catalytic reduction system comprising:

a housing sub-assembly (230) according to any one of Claims 1 to 11 and a pump core, the pump core being located within the pumping zone cavity (248) of the housing sub-assembly.

13. A method of manufacturing a pump assembly comprising manufacturing a housing sub-assembly (230) by:

providing a blank disk member of a material having a relatively high magnetic permeability;
deep drawing the blank disk member to form an outer pole piece, the outer pole piece defining an internal volume with an opening;
inserting a solenoid coil (264) into the internal volume of the outer pole piece (268);
pressing a back stop plate (247) into the outer pole piece (268), the back stop plate having at least one drilling (288) through the plate;
injection moulding an over-mould member (230) to encapsulate the outer pole piece (268) and solenoid coil (264) and to form a main body (232) of the housing sub-assembly (230), the main body having a pump axis (A) and defining a pumping zone cavity having a main axis substantially coincident with axis A, and defining a flow guide cavity disposed about axis A ;
forming a reagent inlet port (234) as part of the over-mould member;
forming coolant ports (236, 238)as part of the over-mould member;
forming a flow path (346) through the over-moulding member, the flow path aligning with the at least one drilling (288) in the back stop plate.

14. A method as claimed in Claim 13, further comprising inserting an actuator pump core into the pumping zone cavity (248) defined by the main body of the housing sub-assembly.

15. A method as claimed in Claim 13 or 14 further comprising inserting a coolant flow guide (254).

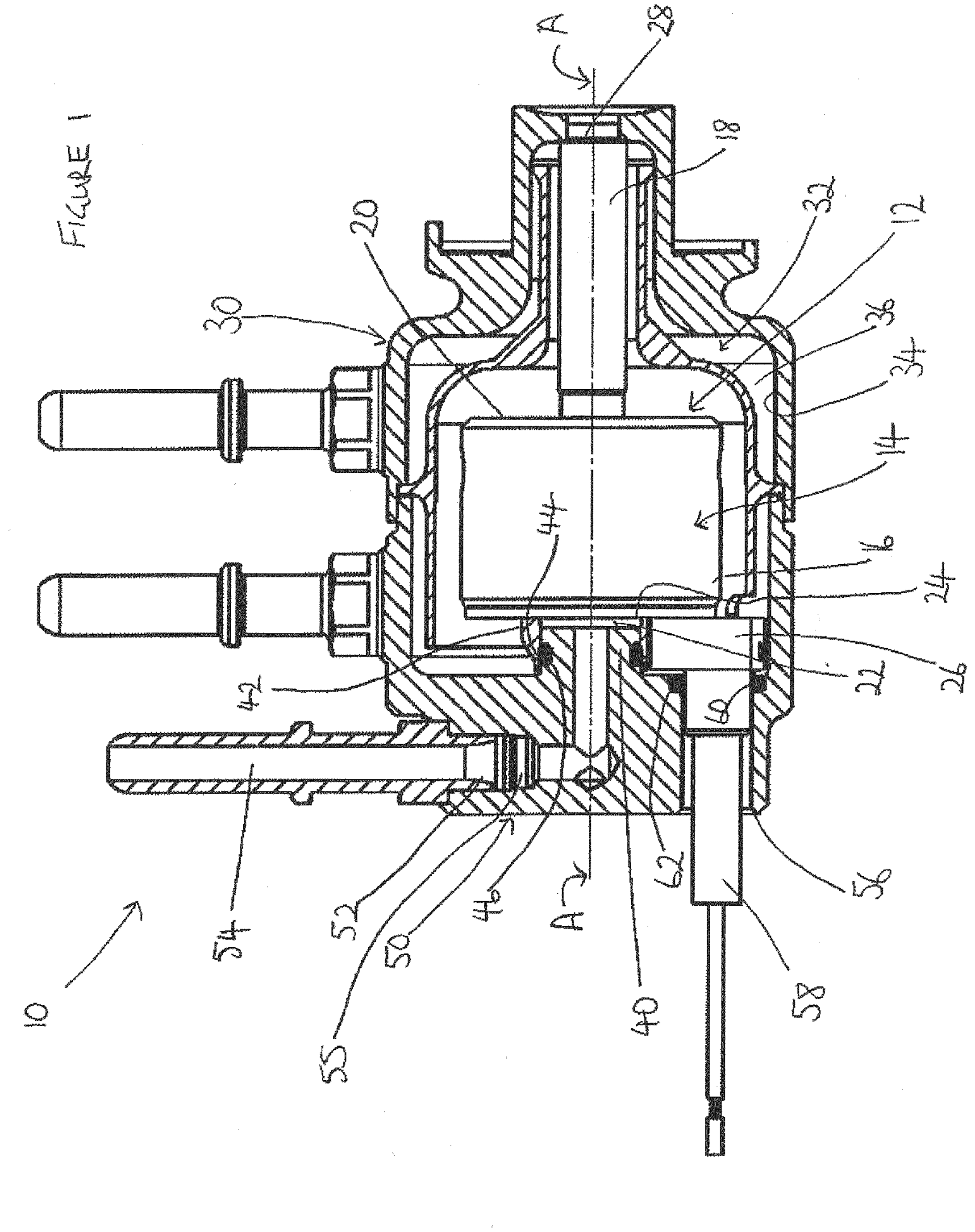
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FIGURE 1

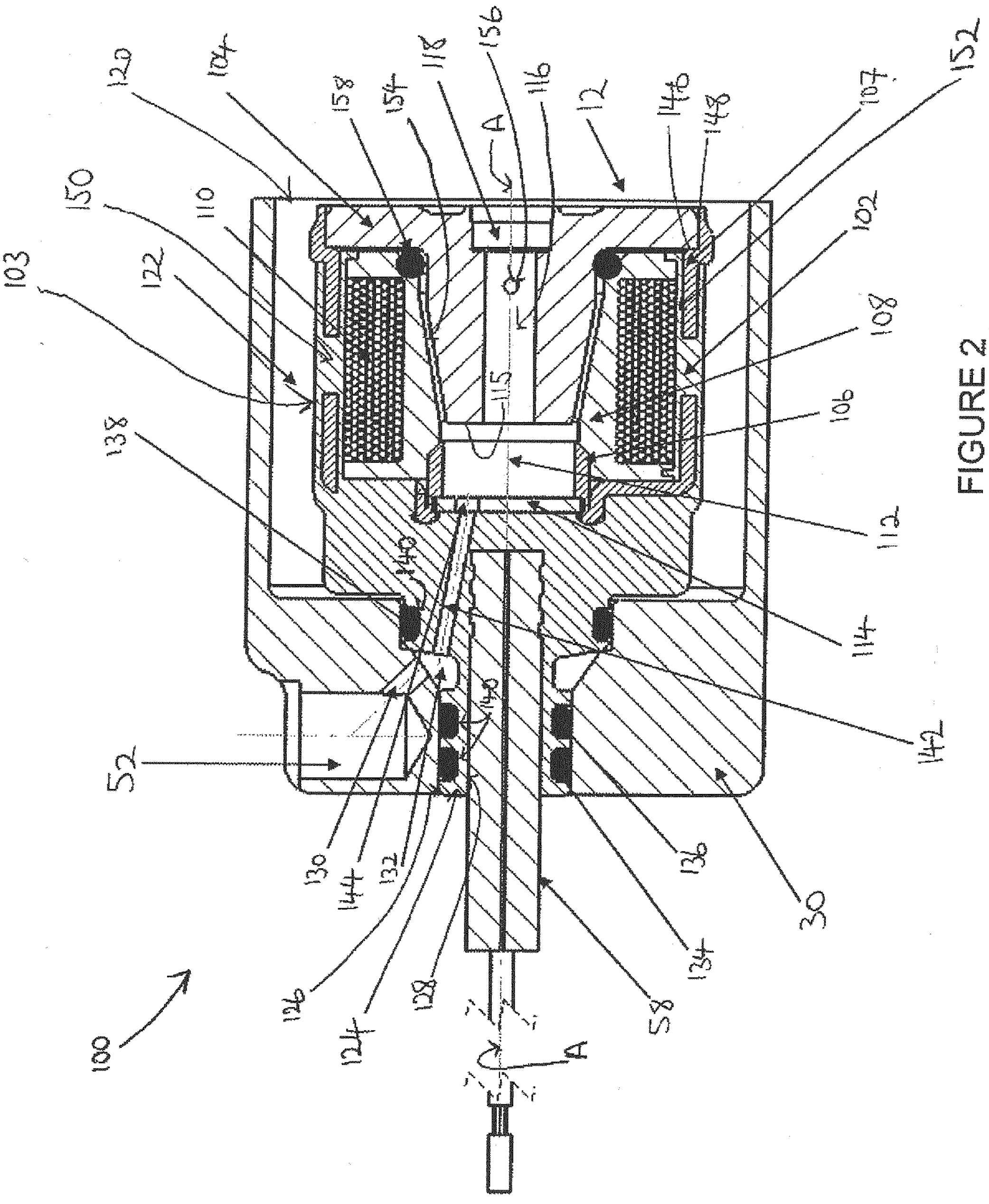
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FIGURE 2

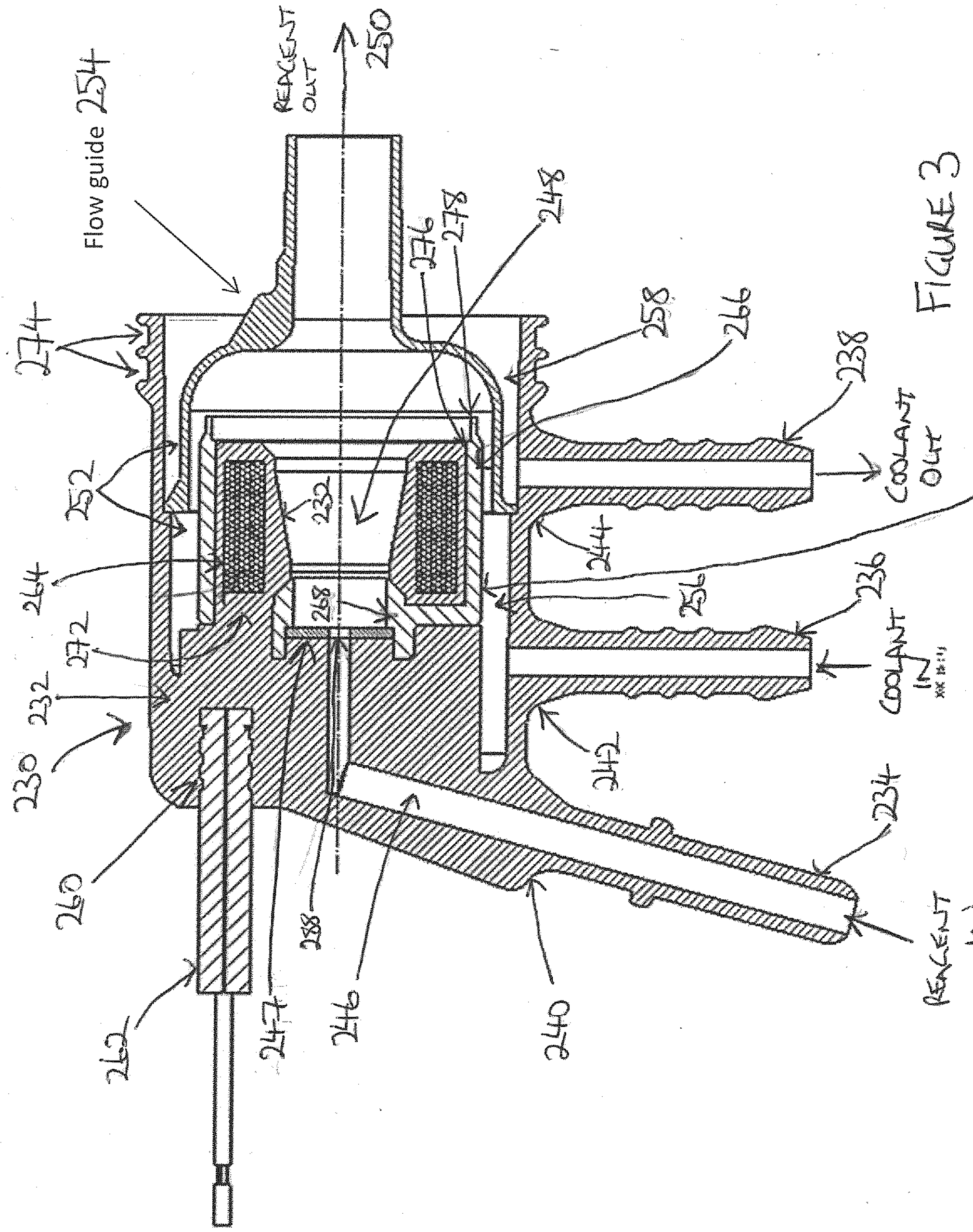
Flow guide 254
REAGENT OUT
250
274
252
264
272
232
230
260
262
247
238
246
240
248
276
278
258
266
238
COOLANT OUT
270
244
256
236
COOLANT IN
242
234
REAGENT IN
268

FIGURE 3

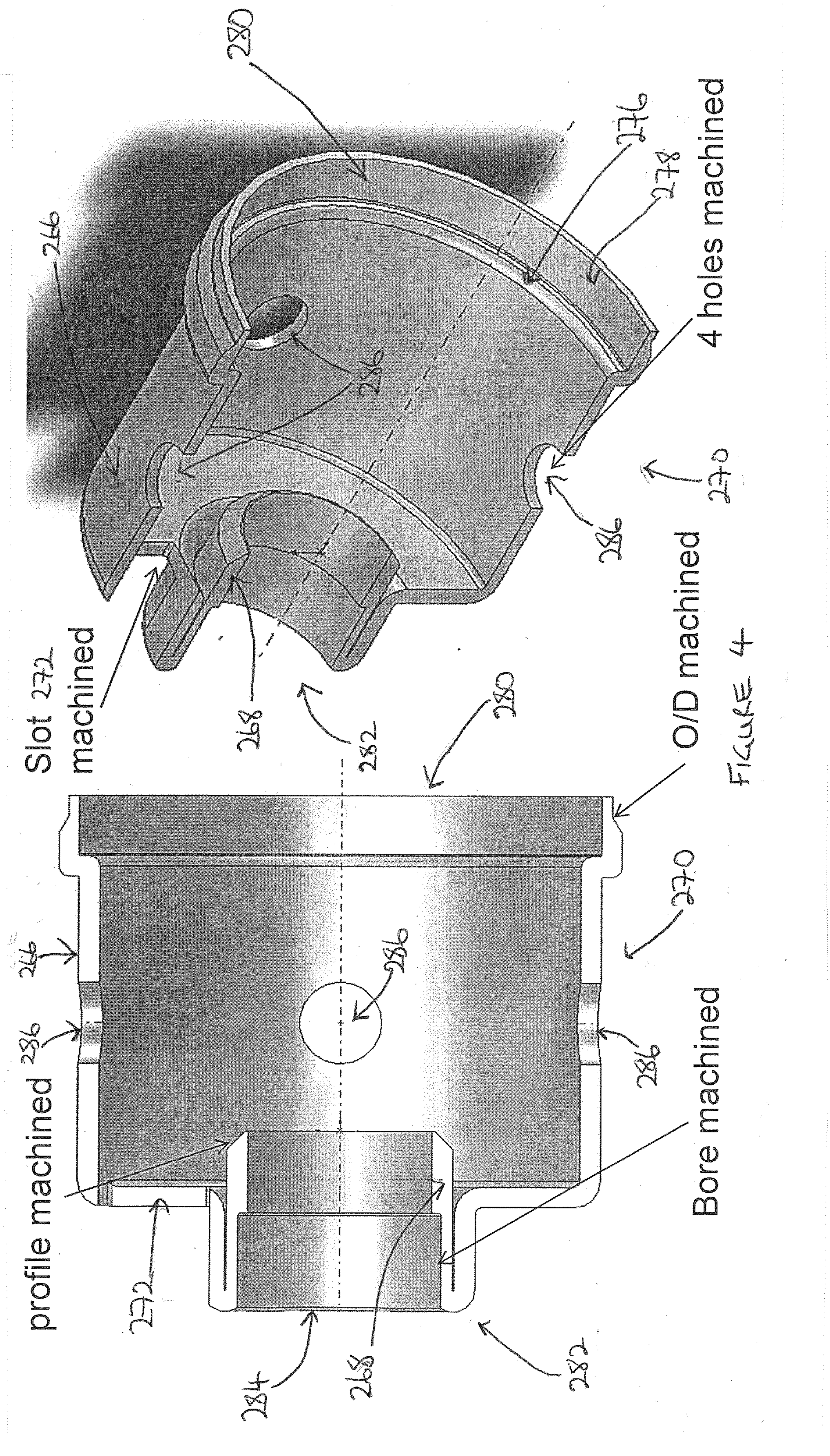
Slot 272 machined
4 holes machined
O/D machined
profile machined
Bore machined
280
266
276
278
286
270
268
282
272
284

FIGURE 4

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EUROPEAN SEARCH REPORT

Application Number
EP 12 18 9726

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2

Place of search	Date of completion of the search	Examiner
Munich	24 January 2013	Ziegler, Hans-Jürgen

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